ONTARIO
Department of Education

Courses of Study

Grades XI and XII

SCIENCE
FOR
VOCATIONAL SCHOOLS
AND
DEPARTMENTS

Issued by Authority of
The Minister of Education

COURSES OF STUDY

For

Grades XI and XII

In

Vocational Schools

SCIENCE FOR INDUSTRIAL DEPARTMENTS

These Courses of Study have been based upon an examination of the scientific requirements of the Shopwork Courses for Vocational Schools.

The presentation of many of the topics in these courses requires discussion by the class. The students should be encouraged, therefore, to make use of suitable reference and illustrative materials, which should be available in a properly indexed form.

Where the scientific principles involved in the study of Electricity, as outlined in these courses, are taught to certain groups in the electrical laboratory, these students should be exempted from the study of this topic. It is recommended that the time allotted for the study of Electricity be devoted to the study of some related optional topics as listed in the Grade XII course.

If time permits, the courses in Vocational Chemistry may be amplified by a study of materials of local importance.

No time allotments have been indicated in the Grade XII course, in order that there may be greater flexibility within the course, and that the time necessary to treat the topics as student-research projects may be made available.

A list of additional research topics is provided at the end of the course in Grade XII Physics. It is suggested that the scientific principles previously outlined be applied in the further study of these topics. Not more than ten per cent of the time should be devoted to this study.

PHYSICS, GRADE XI

Accurate measurements. (Five periods.)

A review of the units of linear measurement in the English and metric systems.

Practice in making fine measurements with a steel rule and calipers.

The construction and use of a vernier scale.

Practice in the use of a micrometer.

Principles and practical applications of machines. —Levers. (Three periods.)

A study of the three classes with an experimental determination of the mechanical advantage of each.

The classification and the use of such levers as are found in the shops.

The determination of the mechanical advantage of such bent levers as the claw hammer and the automobile brake lever.

—Wheel and axle. (One period.)

A review of the wheel and axle and of toothed gears.

—Pulleys. (Two periods.)

A review of pulley systems.

The construction, mechanical advantages and uses of the differential pulley.

—Inclined plane. (Four periods.)

The experimental determination of the mechanical advantage of an inclined plane.

The wedge and the screw as adaptations of the inclined plane.

A study of practical applications of the wedge as in the cam and the carpenter's plane; and of the screw as in the jackscrew and the vise.

Electricity.
—Review. (Three periods.)

A review of current electricity, Grade X, section 12, parts (a), (b), and (c).

—Meaning of potential difference. (Four periods.)

Review the meaning of work, energy and power, with emphasis on gravitational potential energy.

—Direct current motor. (Two periods.)

A simple experiment to illustrate the principle of the D.C. motor. (Details of the structure of the motor are not required.)

—Ohm's Law. (Nine periods.)

A review of electrical units, Grade X, section 12, part (h).

An experiment to determine the resistance of a conductor using the voltmeter-ammeter method.

Simple problems involving Ohm's Law.

—Alternating current (A.C.). (Two periods.)

Simple experiments to show the production of an alternating current: (1) using a bar magnet, coil and galvanometer, and (2) using an electromagnet to replace the bar magnet.

Light.
—Solar spectrum. (Four periods.)

A discussion of light as radiant energy.

An experiment to show the composite nature of white light.

An examination of the colours of the solar spectrum, with a brief discussion of relative wave lengths.

—Transmission of light. (One period.)

The meaning of the terms transparent, translucent, and opaque.

—Reflection and refraction. (Five periods.)

Experiments to illustrate the reflection of light from plane surfaces, and from curved surfaces.

Experiments to illustrate the refraction of a parallel beam of light in passing through a rectangular block of glass, and through a double convex lens.

Experiments to illustrate the refraction of light as it passes from one substance to a substance of different density, and its application to the prism and the convex lens.

A brief discussion of the applications of reflection and refraction of light in modern lighting systems.

—The eye. (Two periods.)

A discussion of the action of the eye in receiving an image, as compared with a camera.

—Colour of bodies in white light. (One period.)

An experiment to show that the colour of a body in white light depends upon the nature of the light waves which it reflects.

—Colour of bodies in coloured light. (One period.)

An experiment to show that a body which appears white in sunlight assumes the colour of any part of the spectrum in which it is placed.

Sound. (Five periods.)

Simple experiments to investigate (1) the origin of sound, (2) the difference in sounds of regular and irregular vibrations, (3) the relation of pitch to vibration number.

A brief discussion of the importance of a knowledge of the nature of sound in locating and correcting defects in machines such as dry bearings, improper meshing of gears, brush contacts in electrical machinery, and body noises in automobile chassis.

A simple experiment to illustrate the effectiveness of sound insulating materials.

A brief discussion of the use of these materials in reducing the transmission of sound as in automobile bodies, machine mountings, and buildings.

CHEMISTRY, GRADE XI

Wood. (Twelve periods.)

A brief discussion of the chemical composition of wood.

Recall the combustion in oxygen and in air, Grade X, section 14.

An experiment to show the effect of heat on wood at various temperatures to the kindling temperature.

A discussion of the meaning of kindling temperature.

A discussion of wood as a fire hazard.

An experiment to illustrate the protection of wood against fire by covering the wood with a fireproof coating such as sodium silicate.

A brief discussion of the use of other protective coverings such as plaster, concrete, whitewash, and asbestos.

An experiment to illustrate the reduction of the fire hazard by impregnating the wood with such chemicals as ammonium phosphate, ammonium sulphate, or borax.

A discussion of the function of these volatile, non-combustible chemicals in diluting the combustible gases given off by the hot wood.

A brief discussion of the fungus decay of wood, and of the conditions necessary for the development of fungi in wood.

Experiments to illustrate the open-tank process and the Kyanizing process for the preservative treatment of wood.

A brief discussion of the methods employed for impregnating wood with preservatives.

The application of kiln drying for the preservation and seasoning of wood.

Refer to the use of paint, varnish, and lacquer for protection from corrosion, Grade X, section 16, part (d), and discuss their application to the preservation of wood.

An experiment to compare the effect of air upon a thin film of linseed oil and of mineral oil.

Spontaneous combustion. (Two periods.)

Recall that combustion is a chemical reaction producing heat energy.

A brief discussion of the causes leading to spontaneous combustion with special reference to such materials as linseed oil, and coal dust.

Limestone and its products. (Five periods.)

A study of limestone, its composition, properties, and uses.

Quicklime; an experimental study of its preparation and properties.

The kinds of quicklime.

Slaked lime (hydrated lime); an experimental study of its preparation and properties.

The action of carbon dioxide on slaked lime.

An experiment to show the preparation of lime-sand mortar, its initial set, and final hardening.

A brief discussion of other uses of slaked lime.

Gypsum and its products. (Five periods.)

A study of gypsum, its composition, properties and uses.

An experiment to show (1) the action of heat on a hydrate such as blue vitriol, and (2) the action of water on the anhydrous residue.

Experiments to show the conversion of gypsum into (1) plaster of Paris, and (2) "hard burned" plaster.

Experiments to show the effect of the addition of water to (1) plaster of Paris, and (2) "hard burned" plaster.

A discussion of other gypsum products such as wallboard, gypsum blocks, and acoustic plaster.

Portland cement and concrete. (Eight periods.)

A study of Portland cement, its composition and properties.

A brief outline of the manufacture of cement.

An experiment to illustrate the setting of Portland cement; a brief explanation of the initial set and of the final hardening.

Recall commercial refractory materials, Grade X, section 2, part (c), and compare the effect of heat on cement after setting.

A study of concrete, its composition and the function of each constituent.

A comparison of the setting of concrete with that of lime-sand mortar.

Recall the expansion of water on freezing, and discuss the application to the disintegration of concrete.

Recall the action of carbonic acid on limestone, and discuss the similar disintegrating action on the calcium salts in concrete.

The uses of concrete.

Petroleum oil products. (Ten periods.)

A discussion of the world locations of petroleum oil, and the methods and channels of distribution, with specific reference to the requirements of the British Empire.

Experiments to illustrate (1) the distillation of water, and (2) the fractional distillation of a water-alcohol solution.

A discussion of the principles of fractional distillation to petroleum refining.

An experiment to show that within certain limits a mixture of gasoline vapour and air will produce an explosive mixture.

A brief discussion of types and grades of motor fuels.

A recall of lubrication and lubricants, Grade X, section 20.

An examination of other petroleum products, with a brief outline of their uses.

Iron and steel. (Seven periods.)

A discussion of the kinds and sources of iron ores.

A discussion of the construction of the iron blast furnace.

Reference to the heat exchange in the stoves.

A demonstration of carbon monoxide as a reducing agent.

Recall the dangerous properties of carbon monoxide, Grade X, section 18, part (e).

An examination of the constituents of the blast furnace charge.

A discussion of the purpose of each substance in the operation of the blast furnace.

A brief discussion of the composition and characteristics of cast iron, carbon steel, and wrought iron.

Density.

A review of the meaning of density.

The determination of the volume of (1) a regular solid such as a cylinder or a prism by linear measurements (using vernier calipers), (2) an irregular solid by displacement.

The measurement of the masses of these solids and the determination of their densities.

Experiments to determine the density of a liquid such as carbon tetrachloride by use of (1) specific gravity bottle, (2) a Westphal plummet, and (3) a hydrometer.

A discussion of methods which may be used to compare the densities of liquids, such as the balancing of immiscible liquids in a U-tube.

Simple problems involving the use of densities to determine volume-mass relations.

An experimental study of the construction of the hydrometer.

A discussion of the various hydrometer scales.

A discussion of the density of water at 4° C. and other temperatures.

A comparison of the meaning of specific gravity and density.

Force.

A review of the meaning of force.

Experiments to determine (1) the equilibrant of two forces acting in the same line (parallel forces), (2) the equilibrant of two forces acting at an angle. The relation of the resultant to the equilibrant.

An experiment to verify the law of the parallelogram of forces.

A discussion of the moment of a force.

A review of the wheel and axle to illustrate the effect of the moment of a force.

Steam heating.

Recall the hot-water heating system.

An experiment to illustrate the heat of condensation (heat of vaporization) of water.

A discussion of the use of steam for heating.

Air-conditioning.

A review of hygrometry.

A discussion of the relation of humidity to health, and of the methods employed for the conditioning of the air of buildings in winter and in summer.

A discussion of the insulation of buildings in relation to the transference of heat; and of air-conditioning.

Magnetic effect of an electric current.

Experiments to demonstrate the magnetic effect of an electric current (1) flowing through a straight wire, (2) flowing through a solenoid, with and without a core.

Experimental investigation of the factors affecting the strength of an electromagnet.

The construction and action of a galvanometer, with a fixed magnet and a moving coil. (The D'Arsenval galvanometer.)

A discussion of the development of the moving-coil galvanometer into an instrument for measuring (1) current (ammeter), (2) voltage (voltmeter).

Simple experiments to illustrate the fundamental principles of (1) the motor, (2) the generator.

The use of a thermocouple and galvanometer to measure temperature (pyrometer).

Light.

A review of reflection and refraction as outlined in Grade XI.

A study of the various types of reflectors with respect to distribution of light rays.

A study of the accepted standards of intensities of illumination used in modern lighting as in (1) home, office, and factory, (2) display effects, (3) floodlighting.

A study of the principles involved and the use of a light meter in measuring the illumination in a room or building.

A discussion of the transmission of light by waves.

The meaning of plane polarized light.

Simple experiments to show the nature and effects of polarized light. (The use of a pair of polaroid discs is suggested.)

A discussion of the uses of such a substance as polaroid, with special reference to the elimination of glare from automobile headlights, and from smooth-surface reflections.

Additional topics.

Photography.
Electronics.
Air-conditioning.
Light-conditioning.
Refrigeration.
Mineralogy.

Combustion.

Experiments to show that certain mixtures of gasoline and air give complete combustion, and that others give incomplete combustion.

A discussion of complete and incomplete combustion of hydrocarbons.

Review the formation of carbon monoxide in the automobile engine, and during the combustion of coal or coke.

Experiments to illustrate the complete and incomplete combustion of acetylene.

The use of the oxy-acetylene flame for welding, with special reference to the correct mixture of oxygen and acetylene.

Repeat the experiment to show the burning of iron in oxygen.

The use of the oxy-acetylene flame for cutting, with special reference to the correct mixture of oxygen and acetylene.

An examination of the structure of the Bunsen burner and its flame.

A discussion of the complete and incomplete combustion of natural gas or coal gas.

A review of explosive mixtures with special reference to the "striking-back" of the flame of the Bunsen burner.

A study of the oxidizing and the reducing zones of the gas flame.

Acids, bases, and salts.

Experiments to show the combustion in oxygen of carbon, sulphur, and red phosphorus; the reaction of these oxides with water, and the effect of their solutions on litmus.

Acidic oxides—acid anhydrides.

An experiment to show the combustion of magnesium in oxygen.

A demonstration of the combustion of sodium in oxygen.

The reaction of these metallic oxides with water, and the effect of their solutions on litmus. Basic oxides.

Discover further properties of acids (dilute) using (1) other indicators, (2) action on carbonates, (3) action on suitable metals (magnesium), (4) taste as shown by soda water, vinegar, sour milk, etc.

Discover the effect of bases on the same indicators as used for acids.

Experiments to show the reaction between acids and bases; the products of the reaction (neutralization), water, and a salt which is left as a residue upon evaporation of the water.

The theory of the ionization of acids, bases, and salts.

A demonstration of the electrolysis of cupric chloride solution, with an explanation in terms of charged particles.

A discussion of the dissociation of hydrogen chloride when dissolved in water as giving rise to electrically charged particles, called ions.

A discussion of the hydrogen ion as being the characteristic ion of acids, and of the properties of acids (taste, effect on litmus and other indicators, action on metals, etc.) as being due to hydrogen ions in the solutions.

A discussion of the dissociation of sodium hydroxide in solution.

A discussion of the hydroxyl ion as being the characteristic ion of bases, and the properties of bases (taste, effect on litmus and other indicators, caustic action on animal and vegetable matter, etc.) as being due to hydroxyl ions in the solutions.

Neutralization.

A discussion of neutralization as being a quantitative reaction depending upon the removal of a hydrogen ion and a hydroxyl ion to form water.

A brief discussion of the measurement of acidity in terms of hydrogen ion concentration. The meaning of pH.

The lead storage cell (the storage battery).

An experiment to show the preparation of the electrolyte.

Recall the use of the hydrometer and discuss the use of the density-concentration tables.

An experiment to "form" a storage cell, using lead plates, with a discussion of the composition of the plates before and after forming.

A discussion of the charging of the cell with special reference to the transformation of electrical energy to chemical potential energy; and the discharging of the cell in terms of the transformation of energy.

The efficiency of the commercial storage battery—a comparison of the output of electrical energy to the input of electrical energy, with a discussion of the dissipation of some energy in heating the cell and decomposing the electrolyte.

Steel.

Review the construction and operation of the iron blast furnace.

A discussion of the construction and use of the iron cupola.

A review of the composition, characteristics and uses of cast iron, carbon steel, and wrought iron.

A brief study of the manufacture of steel by (1) the acid Bessemer process, (2) the basic open-hearth process.

The heat treatment of steel—a discussion of the methods and purpose of annealing, hardening, and tempering of steel.

A discussion of the methods and purpose for surface hardening of steel articles by (1) case hardening, (2) nitriding.

Reference to the composition and characteristics of tool steels.

SCIENCE FOR COMMERCIAL DEPARTMENTS

Since commercial pupils will have taken no science in Grade X, the General Science Course in Grade XI will continue from that of Grade IX. The subject matter should be presented through a practical laboratory course in which experimentation is carried on by the pupils working in small groups. In boys' classes, emphasis should be placed upon industrial application of the principles studied, while in girls' classes, the emphasis should be directed more to home activities.

GRADE XI

Animals and plants in relation to man's interests. (Two periods.)	Various forms of animal and plant life; domesticated animals; value of wild animals. Reference to economic importance of plants.
Fundamental relations of plants to animals. (One period.)	Recall manufacture of food by plants; dependence of animals on plants for food and oxygen; use by plants of carbon dioxide produced by animals.
Bread mould. (Two periods.)	Culture of bread mould and microscopic examination of the mycelium, sporangium, and spores.
Yeast. (Two periods.)	Culture of yeast in sugar solutions and collection and identification of carbon dioxide; microscopic examination of yeast cells; economic importance.
Bacteria. (Five periods.)	What they are and where they occur; beneficial and harmful kinds; laboratory demonstration by the use of Petri dishes and agar to show development of colonies of bacteria; experiments to show (1) pasteurization of milk, (2) sterilization of milk and of canned foods; water pollution; purification of water by boiling; use of chloride of lime as a disinfecting agent; infectious diseases, e.g., tuberculosis, typhoid fever, diphtheria; discussion of agents of infection, such as house flies, drinking cups, etc.
The human body. —The cell. (Four periods.)	Recall the structure of a plant cell. Microscopic observation of a simple cell such as cheek epithelium to show cell wall, cytoplasm and nucleus; growth (1) by increase in size of cells, (2) by increase in the number of cells (cell division). The cell as an organism with the functions of nutrition, motility and secretion. (If possible, the living amoeba or paramoecium should be examined by the pupils.) The meaning of tissues, organs, systems.
—Digestion and absorption. (Six periods.)	Carbohydrates—an experiment to show the presence in starch of (1) carbon, (2) hydrogen and oxygen (as shown by the condensation of water). An experiment to show the conversion of starch to sugar by the action of saliva. Fats—the composition of fats; experiments to show that fats (1) are insoluble in water, (2) are soluble in carbon tetrachloride, (3) produce a persistent greasy translucent spot on paper.

Proteins—the composition and occurrence of proteins; experiments to show (1) that proteins are characterized by a disagreeable odour on charring, (2) the spot test with nitric acid and ammonium hydroxide.
The meaning of digestion; the alimentary canal; a brief discussion of digestive changes taking place in each of the parts; glands and juices taking part in these changes.
Absorption of digested food.

—Circulation, respiration, and excretion. (Seven periods.)

The blood and the lymph: observation of the circulation of blood in the web of a frog's foot or in a tadpole's tail; microscopic examination of a drop of blood diluted with physiological saline solution (0.9% sodium chloride).
The constituents of the blood and their functions.
The circulation of the blood in the human body (names of arteries and veins are not required); the changes taking place in the tissues, the kidneys, and the lungs.
Protection from disease by the formation of anti-bodies.
An experiment to show that exhaled air contains more carbon dioxide than air in a room; the meaning of respiration (energy transformation).
The organs of breathing; the great surface area in the lungs; how breathing is carried on.

Heat.
—Heat units. (Four periods.)

Comparison of Fahrenheit and Centigrade scales by means of a graph.
An experiment to illustrate the meaning of quantity of heat; the distinction between quantity of heat and temperature.
The calorie and the B.T.U.
Experiments to investigate the heat capacity of different substances.
The importance of the high heat capacity of water in relation to climate.

—Heat transference. (Four periods.)

Recall convection currents in water, and the hot-water heating system.
Experiments to investigate the heat conductivity of various metals.
An experimental study of commercial insulating materials.
A discussion of the use of insulating materials in building.

—Hygrometry. (Four periods.)

Recall presence of water vapour in the air.
An experiment to determine dew-point.
Meaning of relative humidity.
Measurement of the relative humidity of the air in the classroom by means of the wet and dry bulb hygrometer, and the hair hygrometer.
The meaning of air-conditioning; humidifiers.

Electricity. (Ten periods.)

An experiment to show the production and detection of a current from a voltaic cell. The dry cell as a special form of the voltaic cell.
An experiment to classify electrical conductors and non-conductors.
An experiment to show the transformation of electrical energy into heat energy; reference to electric heaters, fuses, and lamps.

A discussion of the efficiency of electric lamps; direct and indirect lighting; proper illumination for reading.
Switches, fuses, short circuits, danger of grounds in household circuits; the necessity for grounding.
An elementary discussion of electrical units—volt, ampere, watt, kilowatt-hour—in relation to common electrical appliances and in payment for electrical energy.

Light.

—The solar spectrum. (Four periods.)

A discussion of light as radiant energy.
An experiment to show the composite nature of white light.
An examination of the colours of the solar spectrum, with a brief discussion of relative wave lengths.

—Transmission of light. (One period.)

The meaning of the terms transparent, translucent, and opaque.

—The eye. (Four periods.)

A discussion of the action of the eye in receiving an image, as compared with a camera.
The capacity for distinguishing chromatic colours, and its absence in cases of colour-blindness.

—The colour of bodies in white light. (Three periods.)

An experiment to show that the colour of a body in white light depends upon the nature of the light waves which it reflects.
A brief discussion of transparent glazes and of water-colour paints as absorbers of various light waves.

—The colour of bodies in coloured light. (Three periods.)

An experiment to show that a body which appears white in sunlight assumes the colour of any part of the spectrum in which it is placed.
An experiment to show that a body having colour in white light reflects wave lengths of that colour and absorbs light of other wave lengths.

—The colour of bodies in artificial light. (Three periods.)

A discussion of the composition of artificial light as compared with sunlight.
The effect of lack of some light waves in artificial light on the colour of coloured bodies, for example, the colour of a red pigment under a mercury-vapour lamp, or of blue and violet pigments under the incandescent lamp; stage lighting for colour effects.

Water.

—Municipal water supply. (Fifteen periods.)

Recall the study of water as outlined in Grade IX.
A practical study of the supply, purification, and use of water in an urban municipality.

Sand filtration:

(a) Clarification: the effect upon the grains of sand in the bed of adding aluminium sulphate (filter alum); an experimental illustration of the clarification of a clay suspension (the explanation not to involve chemical formulae).
(b) Detention of bacteria: recall past reference to harmful bacteria.

Chlorination: an explanation of its purpose (not to involve chemical formulae).
A laboratory demonstration by the use of Petri dishes and

agar to show development of colonies of bacteria from samples of water taken from (1) source, (2) the tap.
An experiment to prepare a sample of chemically pure water by distillation.
An experimental comparison of tap water, rain water, and distilled water as regards (1) dissolved substances, (2) the action on soap solution.

An experimental study of the methods used to soften water (1) in the home, (2) in industry.
A discussion of the importance of softening water (1) for laundry purposes, (2) for the prevention of boiler scale, (3) for the dyeing of textiles.

Common salt.
(Six periods.)

A study of the properties of sodium chloride, such as colour, taste, solubility in hot and cold water.
Experiments to prepare (1) a saturated solution of common salt, (2) crystals by slow evaporation of this solution.
A brief outline of the methods used for the recovery of salt from commercial deposits.
A demonstration of the production of sodium hydroxide and chlorine by the electrolysis of salt brine.
A discussion of the uses of salt and of its products in industry. (This discussion should be amplified by an examination of the materials.)

Fuels.
(Eight periods.)

Coal:
A discussion of the formation and the sources of coal deposits.
An experimental study of the properties of anthracite coal, bituminous coal, and lignite with respect to appearance, hardness, and the effect of strongly heating a sample of each in a small covered crucible.
A brief discussion of the coal gas plant, or the by-product coke oven, with respect to the production of coke, coal gas ammonia, and other important by-products. (A diagram of the plant is not required.)
Petroleum oil products:
A discussion of the world locations of petroleum oil, and the methods and channels of distribution, with specific reference to the British Empire.
An experiment to illustrate the fractional distillation of a water-alcohol solution.
A brief discussion of the application of the principles of fractional distillation to petroleum refining.
A brief discussion of types, grades, and uses of petroleum products.
Fuel gases:
A comparison of artificial and natural gases with respect to sources and characteristics.

Iron and steel.
(Four periods.)

A discussion of the kinds and sources of iron ores.
A brief discussion of the composition, characteristics, and uses of cast iron, steel, and wrought iron.

SCIENCE FOR COMMERCIAL DEPARTMENTS
GRADE XII

A course in Science for Grade XII, Commercial Departments, will be issued for the year 1940-41.

SCIENCE FOR AGRICULTURAL DEPARTMENTS

The Science Course for agricultural departments will consist of the topics in Science presented for Agricultural Science of Grades XI and XII of the General Course.

SCIENCE FOR ART AND HOME ECONOMICS DEPARTMENTS

No course in science for these departments has been prepared for this year. Teachers will continue with the courses they have used in the past year with such modifications as may be necessary.